Material System for Intermediate Temperature Solid Oxide Fuel Cell

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ABSTRACT

The objective of this project is to investigate a material system for making and evaluating planar intermediate-temperature solid oxide fuel cells that are capable of operating at (50-90% fuel utilization) power density greater than 0.6 W/cm^2 at 500^{o}C and 1 W/cm^2 at 700^{o}C and have less than 1% long-term degradation in electrical performance.

Project achievements:

- Work in this performance period has focused on characterizing the charge-transfer polarization of electrolyte-cathode interfaces.
- A setup to characterize charge-transfer polarization separately at the electrolyte-cathode and electrolyte-anode interfaces has been built and is functional.
- Symmetrical cells consisting of cathode material on both sides, e.g. [air,$La_{0.9}Sr_{0.1}MnO_3$/LSGM/ $La_{0.9}Sr_{0.1}MnO_3$,air] have been fabricated using conventional powder processing, slurry-dip coating and sintering.
- Electrochemical characterization using AC complex impedance spectroscopy of the symmetrical cells described above to extract the effective charge-transfer polarization resistance of LSM ($La_{0.9}Sr_{0.1}MnO_3$), LSCF ($La_{0.6}Sr_{0.4}Co_{0.8}Fe_{0.2}O_3$) and Pt cathodes in the temperature regime of 600-800^{o}C. Work on LSCF-LSGM composite cathodes is still ongoing.

Experimental:

Doped-lanthanum gallate of the composition $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$ (LSGM-9182) is the electrolyte used in this work. LSGM-9182 powder was synthesized from standard powder mixing and calcination routes using carbonate and oxide precursors. The powders will milled to sub-micron particle sizes and pressed into pellets using a uniaxial die press. The uniaxially pressed pellets were sintered in the temperature range of 1300-1450^{o}C and resulted in greater than 95% theoretical density.

The electrode powders were also made using a similar mixing and calcination route and milled to particle sizes of 1-2 microns. The fine cathode particles were dispersed in slurry (solvent: alpha-terpenol). The sintered LSGM pellets were masked to result in a ~1.5 cm^2 circular electrode

symmetrically applied to both sides of the LSGM pellet by dipping it into the electrode slurry and withdrawing it at a controlled rate. The slurry dip-coated electrodes were fired at 1100-1200^{o}C. Electrolyte-electrode cross sections were characterized using scanning electron microscopy (SEM). The resulting electrodes had a fine microstructure (1-3 micron grain size and porosity), were well adhered to the electrolyte and ranged in sintered thickness from 10-30 microns.

The symmetrical cells fabricated using the technique described above were characterized using AC complex impedance spectroscopy to separate the ohmic and charge-transfer resistances of the cells.

Results and discussion:

Of the cathodes characterized using the symmetrical cell technique, LSM had the largest charge-transfer polarization resistance (R_{ct}^{eff}) at a given electrode thickness. The R_{ct}^{eff} of the LSM-LSGM particulate composite cathode was comparable to the Pt electrode (30.9 $\Omega.cm^2$) while that of the LSCF electrode was more than ***two orders of magnitude*** lower at 750^{o}C (0.13 $\Omega.cm^2$). The same trend of lower R_{ct}^{eff} for LSCF electrode compared to other electrodes was also observed at other temperature. Further, the R_{ct}^{eff} of the LSCF electrode showed a thickness dependence; i.e. with increasing electrode thickness a decreasing R_{ct}^{eff} was observed. This type of thickness dependence has also been observed in prior work by other research groups for composite electrode comprising LSM-YSZ cathodes with a YSZ electrode. Based on the results we have obtained thus far, we have tentatively identified LSCF as the cathode of choice in our ongoing research.

Ongoing work

- Complete thickness dependence characterization of LSCF cathodes and measurement of R_{ct}^{eff} in LSCF-LSGM composite cathodes.
- Anode development and cell process development

Presentations

1) S.Gopalan, Materials research for solid oxide fuel cell (SOFC) technology, Invited talk SUNY-Stonybrook Center for Thermal Spray, April 11, 2003.

Students/post-doc receiving support: Wenquan Gong and Chris Manning